



## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<b>(51) International Patent Classification:</b> <b>B65G 53/52, F16L 11/12,</b> <b>F16L 57/00, G01M 3/18</b>	<b>A1</b>	<b>(11) International Publication Number:</b> <b>WO 00/61472</b> <b>(43) International Publication Date:</b> 19 October 2000 (19.10.2000)
<b>(21) International Application Number:</b> PCT/US99/07899 <b>(22) International Filing Date:</b> 12 April 1999 (12.04.1999) <b>(60) Parent Application or Grant</b> THE GOODYEAR TIRE & RUBBER COMPANY [/]; (). CHEVALIER, Ronald, Marcel [/]; (). COOK, Andre, Georges [/]; (). HUTCHINS, Thomas, Goodsell [/]; (). CHEVALIER, Ronald, Marcel [/]; (). COOK, Andre, Georges [/]; (). HUTCHINS, Thomas, Goodsell [/]; (). COHN, Howard, M. ; ().		<b>Published</b>
<b>(54) Title: ABRASIVE MATERIAL TRANSPORT HOSE WITH WEAR DETECTING SENSORS</b> <b>(54) Titre: TUYAU FLEXIBLE DE TRANSPORT D'UNE SUBSTANCE ABRASIVE AVEC DETECTEURS D'USURE</b>  <b>(57) Abstract .</b> <p>The useful life of an abrasive material transport hose (10) can be maximized if the hose is repositioned at the first signs of internal wear. This is accomplished by disposing at least two wear sensing elements (17, 21), each at a specified distance from the inwardmost surface of the inner tube (12), and each monitoring a condition indicative of wear of the hose (10) at its specified distance from the inwardmost surface of the inner tube. When the innermost wear sensing element (17) implies wear, the hose can be repositioned to extend the useful life until the outermost wear sensing element (21) indicates wear requiring replacement of the hose.</p> <b>(57) Abrégé</b> <p>La durée de vie utile d'un tuyau flexible (10) conçu pour transporter une substance abrasive peut être rallongée si l'on repositionne ce tuyau flexible dès les premiers signes d'usure intérieure. A cet effet, on dispose au moins deux éléments détecteurs d'usure (17, 21) à une distance définie de la surface située le plus à l'intérieur de la partie intérieure du tuyau (21), chacun de ces éléments étant destiné à contrôler, à une distance définie de la surface située le plus à l'intérieur de la partie intérieure du tuyau, un état indiquant l'usure dudit tuyau flexible (10). Ainsi, lorsque l'élément détecteur d'usure (17) placé le plus à l'intérieur signale l'usure, on peut repositionner le tuyau flexible afin de rallonger la durée de vie utile de ce dernier, jusqu'à ce que l'élément détecteur d'usure (21) placé le plus à l'extérieur indique qu'il est nécessaire de remplacer ce tuyau.</p>		

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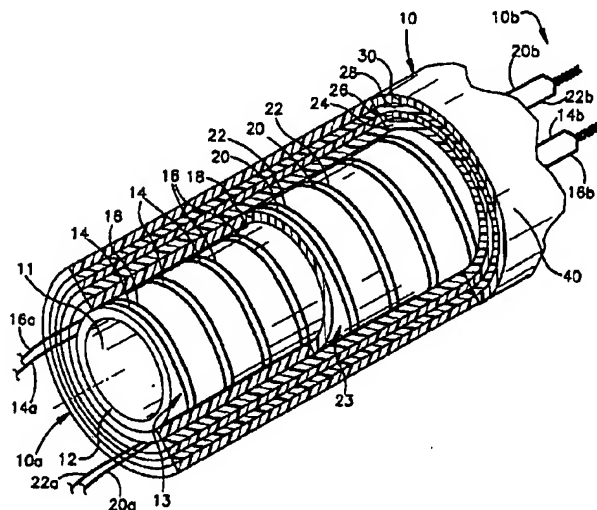
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<b>(21) International Application Number:</b> PCT/US99/07899 <b>(22) International Filing Date:</b> 12 April 1999 (12.04.99)  <b>(71) Applicant (for all designated States except US):</b> THE GOODYEAR TIRE & RUBBER COMPANY [US/US]; 1144 East Market Street, Akron, OH 44316-0001 (US).  <b>(72) Inventors; and</b> <b>(75) Inventors/Applicants (for US only):</b> CHEVALIER, Ronald, Marcel [CA/CA]; 96 Mailloux Street, St-Luc, Québec J2W-1S1 (CA). COOK, Andre, Georges [CA/CA]; 389 Gerard Choquette, Granby, Québec J2H-1V6 (CA). HUTCHINS, Thomas, Goodsell [US/US]; 11937 Basswood Avenue NW, Uniontown, OH 44685 (US).  <b>(74) Agent:</b> COHN, Howard, M.; c/o Robert W. Brown Dept. 823, The Goodyear Tire & Rubber Company, 1144 East Market Street, Akron, OH 44309-3531 (US).			<b>(81) Designated States:</b> AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).  <b>Published</b> <i>With international search report.</i>

**(54) Title:** ABRASIVE MATERIAL TRANSPORT HOSE WITH WEAR DETECTING SENSORS



**(57) Abstract**

The useful life of an abrasive material transport hose (10) can be maximized if the hose is repositioned at the first signs of internal wear. This is accomplished by disposing at least two wear sensing elements (17, 21), each at a specified distance from the inwardmost surface of the inner tube (12), and each monitoring a condition indicative of wear of the hose (10) at its specified distance from the inwardmost surface of the inner tube. When the innermost wear sensing element (17) implies wear, the hose can be repositioned to extend the useful life until the outermost wear sensing element (21) indicates wear requiring replacement of the hose.

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**ABRASIVE MATERIAL TRANSPORT HOSE WITH WEAR DETECTING  
SENSORS**

**FIELD OF THE INVENTION**

The invention relates to a hose for transporting abrasive material and in particular to a hose for transporting abrasive material having sensors for detecting wear of the hose.

**BACKGROUND OF THE INVENTION**

A hose for transporting abrasive material, either fluidized or dry bulk, is usually constructed with an inner lining or tube made of abrasion resistant material, a carcass composed of layers of reinforcement plies to resist pressure within the tube and a rubber cover, typically of an elastomeric materials, to protect the carcass. The hose may include, a reinforcing steel wire helix embedded between the layers and a built-in coupling at each end.

Since the hose is used for transporting abrasive material, the inner lining and reinforcing layers of the hose can be worn through by the flow of the material during usage. Since the wear is within an internal section of the hose, it is not possible to visually inspect the degree of wear. The hose, if operated until total failure, can create unforeseeable and unwanted problems including leakage, rupture or explosion.

U.S. Patent No. 4,446,892 ('892) by Maxwell discloses a fluid transport hose having two or more plies comprising a sensing element located between the plies, the sensing element being adapted to respond to the failure of an inner ply of the hose by presenting an open circuit. The purpose of the sensing element in the hose is to detect imminent breakdown of a hose section and to permit the user to replace the hose prior to external leakage. The '892 patent also discloses a secondary sensing element disposed between the

5           outermost plies of the hose to detect the occurrence of  
physical damage to the outer plies of the hose.

          U.S. Patent No. 5,634,497 ('497) by Neto discloses a  
10           hose for suction and discharge of abrasive material with a  
5           sensor circuit which indicates the total or partial wear of  
the inner lining of the hose, thus permitting hose  
replacement prior to its rupture or blow up. The '497 patent  
15           discloses a sensing element comprised of a bi-polar (two-  
pole) socket fixed to one of the external layers of the hose  
10           and connected, preferably, to the terminal ends of wires  
which extend spirally along the entire length of the hose.  
20           In order to determine the wear of the hose, it is necessary  
to verify, by means of the bi-polar socket, the continuity of  
the sensing element. In the case where the sensing element  
15           is interrupted, this means that the wire wound within the  
25           hose has been broken, implying that the hose shows signs of  
internal wear and should be replaced.

#### OBJECTS AND SUMMARY OF THE INVENTION

30           It is an object of the present invention to provide an  
20           improved hose using a sensing system to detect the internal  
wear of a hose, as defined in one or more of the appended  
claims and, as such, having the capability of being  
35           constructed to accomplish one or more of the subsidiary  
objects.

25           It is another object of the present invention to provide  
a hose capable of transporting abrasive material, either dry  
40           bulk or fluid.

          It is a further object of the present invention to  
detect wear of the hose without interrupting the transport of  
30           the abrasive material.

45           It is yet another object of the present invention to  
detect wear of the hose to avoid an operating accident such  
as leakage, rupture, and explosion.

          It is still another object of the present invention to  
50           35           provide multiple levels of hose wear detection in order to

5 permit hose reposition prior to replacement in order to maximize the hose's useful life.

10 It is an object of the present invention to provide a hose with a wear-sensing element, which can be disposed  
5 within the tube or between the reinforcement plies of the hose using either wire or chemically sensitive tape.

15 In accordance with the invention, a hose for transporting abrasive material comprises first and second wear-sensing elements, one disposed at a first distance from  
10 the innermost surface of the inner lining (tube) and a second disposed at a second distance from the innermost surface of the inner lining (tube), the second distance being greater  
20 than the first distance. By monitoring the first and second wear-sensing elements with wear sensing devices, it is  
15 possible to detect wear of the inner lining and further wear as it propagates to one of the many layers disposed over  
25 (radially outward) the inner lining.

30 The first wear-sensing element is disposed adjacent to or within the inner lining (tube) or one of the reinforcement plies, running substantially the entire length of the hose.  
20 The first wear-sensing element, made up of a first set of two sensor wires, extends spirally over the length of the hose. One end of the first set of two sensor wires making up the  
35 first wear-sensing element are joined together. The other  
25 end of the first set of two wires making up the first wear-sensing element are connected to a first two-pole socket.

40 The second wear-sensing element comprises a second set of two sensor wires, each of the two sensor wires having one end extending to or even beyond one end of the hose and an  
30 opposite end extending to or even beyond the other end of the hose and joined (spliced) together. At the one end of the  
45 hose, the second set of sensor wires are connect to a second two-pole socket.

50 The means or structural components to detect wear is  
35 provided by connecting to the first and second two-pole

5 sockets, through which the first and second wear-sensing  
elements can be monitored. Sensing wear at the first,  
innermost wear-sensing element permits the user to reposition  
10 the hose so as to continue operation until wear is sensed at  
5 the outermost second wear-sensing element, at which point the  
hose needs to be replaced prior to its failure during use.  
Repositioning the hose after sensing wear in the innermost  
15 layers of the hose extends the useful life of the hose.

#### BRIEF DESCRIPTION OF THE DRAWINGS

10 The structure, operation, and advantages of the present  
preferred embodiment of the invention will become further  
20 apparent upon consideration of the following description  
taken in conjunction with the accompanying drawings, wherein:

25 **FIGURE 1** is a perspective view, partial cutaway, of a  
section of an embodiment of a hose of this invention  
incorporating sensor wire applied over the length of the  
hose;

30 **FIGURE 2** is a perspective view of the hose of **FIGURE 1**,  
showing a later stage of construction, incorporating two-pole  
20 sockets connected to sensor wire and assembled on the hose;

35 **FIGURE 3** is a perspective view of the hose of **FIGURE 2**  
showing a completed hose of this invention, incorporating two  
wear sensor circuits and a wear-sensing device attached to  
each circuit;

40 **FIGURE 4** is a detailed view of a wear-sensing device of  
**FIGURE 3**, including local annunciation and optional remote  
station connection;

**FIGURE 5** is a simplified schematic block diagram of a  
hose wear-sensing device of **FIGURE 4**; and

45 **FIGURE 6** is a perspective partial cut-away view of a  
section of another embodiment of a hose of this invention.

#### DETAILED DESCRIPTION OF THE INVENTION

50 A hose for transporting abrasive material wears due to  
the effects of contact with the material being transported.  
35 Wear initiates on the inner lining and then propagates to

5 subsequent reinforcement layers until total failure of the hose occurs, resulting in leakage, rupture, or explosion.

From the prior art, it is known that wire may be disposed in a hose in order to detect the wear of inner  
10 5 layers to permit replacement prior to total failure of the hose. Wire used for this purpose is called "sensor wire". A "wear sensing element" comprises a layer of sensor wire in a hose. A layer of hose surrounded by a wear-sensing element is called a "sensed layer". A device used to monitor a wear  
15 sensing element is called a "wear sensing device". A "wear sensing system" comprises a wear sensing device attached to a wear sensing element.  
20

A sensed layer, either an inner lining (also called a tube herein) or a reinforcement ply covering the tube, wears  
15 due to the effects of the abrasive material being transported. Once the sensed layer has worn through, the abrasive material can make contact with and cause wear of the sensor wire in the wear sensing element. A wear sensing  
25 system determines whether the wear sensing element is worn by testing for continuity. The presence of continuity of the wear sensing element implies that the sensed layer is not worn. Conversely, the absence of continuity of the wear  
30 sensing element implies wear of the sensed layer.

A hose of the present invention includes at least two  
35 25 distinct wear sensing elements. The use of multiple wear sensing elements permits the detection of wear at different depths of the hose. As is commonly understood in the industry, the wear of a hose in abrasive material applications typically occurs at specific points within the  
40 hose, typically where the hose has a bend in it. The wear sensing element for the innermost sensed layer provides the first indication of hose wear. Wear detected at the innermost sensed layer permits the user to know when a hose should be repositioned (typically rotated) to transfer the  
45 material abrading to other locations of the hose inner  
50 35



5 layers, thereby extending the useful life of the hose. This  
process can be repeated until wear is detected in the  
outermost wear sensing element, implying wear in the  
10 outermost sensed layer, indicating the need for hose  
5 replacement.

The aforementioned U.S. Pat. No. 5,634,497 to Neto  
discloses a hose with two layers of sensor wire arranged so  
15 as to form only one wear sensing element. In contrast  
thereto, the hose of the present invention has at least two  
10 wear sensing elements and corresponding at least two wear  
sensing systems arranged such that, in the case of two wear  
20 sensing elements, the inner wear sensing element detects the  
initiation of wear in the inner lining and the outer wear  
sensing element detects propagation of wear to a subsequent,  
15 outwardly disposed reinforcement layer.

25 U.S. Pat. No. 4,446,892 to Maxwell discloses a hose with  
two wear sensing elements, the sensing elements arranged such  
that the inner sensing element detects wear in the inner  
30 lining, and the outer sensing element detects damage to the  
20 hose exterior. In contrast thereto, the at least two sensing  
elements of the present invention are arranged such that the  
progress of a wear problem can be "tracked" as it propagates  
from the inner lining to subsequent reinforcement layers.

35 **FIGURE 1** shows a preferred embodiment of the hose 10 for  
25 transporting abrasive material of the present invention in a  
partially completed stage of construction. The hose 10 has  
two ends 10a and 10b, and comprises an inner, preferably  
40 wear-resistant elastomeric lining (tube or tubes) 12 having  
an innermost surface 11. A first set of sensor wires 14 and  
30 16 are spirally wound on the inner lining 12 and extend to or  
even beyond both ends of the hose 10. The first ends 14a and  
45 16a of the sensor wires 14 and 16, respectively, extend to or  
even beyond the end 10a of the hose 10 and are connected to a  
two-pole socket 42. The opposite second ends 14b and 16b of  
50 the sensor wires 14 and 16, respectively, extend to or even

5           beyond the opposite end 10b of the hose 10 and are connected  
(spliced) to one another.

10           In this manner, the two sensor wires 14 and 16  
effectively form a single wear sensing element 17 extending  
5   along the entire length of the hose 10 over a "sensed layer"  
13. The single wear sensing element 17 has two ends 14a and  
16a which typically extend to one end 10a of the hose 10. As  
15   described hereinbelow, the 'free ends' 14a and 16a of wires  
14 and 16, respectively, are connected to a conventional two-  
10   pole socket 42, and a wear sensing device 60 is attached to  
the wear sensing element 17 via the socket, to form a "wear  
20   sensing system" 19. According to the invention, additional  
wear sensing elements 21 may be formed in the hose 10 to  
monitor progress of abrasion as it propagates from the sensed  
15   layer 13 of the hose towards an outer sensed layer 23 of the  
25   hose.

          The second sensed layer 23 of tube or reinforcement ply  
is applied over the wear sensor wires 14 and 16. In a manner  
similar to that described hereinabove with respect to the  
30   wear sensing element 17, a pair of sensor wires 20 and 22 are  
spirally wound around the layer 18 of reinforcement ply and  
typically extend to or even beyond both ends 10a and 10b of  
the hose 10. The free ends 20a and 22a of the sensor wires  
35   20 and 22 can extend to or beyond the end 10a of the hose 10  
25   and are connected to a conventional two-pole socket 44. The  
ends 20b and 22b of the sensor wires 20 and 22 extend to or  
beyond the opposite end 10b of the hose 10 and are connected  
40   (spliced) to one another to complete a second wear sensing  
element 21. The wear sensing element 21 is used to detect  
30   wear in the "sensed layer" 23.

45           In this manner, two wear sensing elements 17, 21 are  
provided in the hose 10. The first wear sensing element 17  
comprises the sensor wires 14 and 16 and is disposed at a  
first distance from the most inner surface 11 of the inner  
50   lining 12. The second wear sensing element 21 comprises the  
35

5 sensor wires 20 and 22 disposed at a second distance which is greater than the first distance from the most inner surface 11 of the inner lining 12.

10 Additional layers of reinforcement ply, as represented by ply layers 24, 26, 28, 30 (24-30), are disposed over the sensed layers 12 and 23. In addition, reinforcing steel wire helix wires (not shown) can be embedded between the ply layers as is conventionally known in the hose construction art. In the manner described hereinabove, additional wear 15 sensing elements can be incorporated into the hose construction, over any one of these additional ply layers, at increasing distances from the inner surface 11 of inner lining 12, to provide additional levels of wear detection, as may be desired.

20 **FIGURE 2** shows a further stage of construction of the hose 10 of the present invention. On the outmost shown layer 40 of reinforcement ply, first and second two-pole sockets 42,44 are affixed by any conventional means, and are connected to free ends 14a,16a and 20a,22a, respectively, of the sensor wires 14,16 and 20,22 of sensing elements 17,21, 25 respectively. At the opposite end of the hose 10, free ends 14b,16b,20b,22b of the sensor wires 14, 16 and 20, 22 are spliced together as shown in **FIGURE 1**. While the wires 14,16 and 20,22 are shown spliced together, it is within the terms of the present invention to join them in any conventional 30 manner including forming them of a single length of sensor wire. As shown in **FIGURE 2**, sensor wires 14,16 and the first two-pole socket 42 represent the first wear sensing element 17 and sensor wires 20,22 and second two-pole socket 44 35 represent the second wear sensing element 21.

40 **FIGURE 3** shows a completed construction of a typical hose 10 of the present invention. The hose 10 receives an outermost cover layer 50 to protect the plies 24-30 forming the hose carcass, thus enclosing the two-pole sockets 42,44 45 (shown in **FIGURE 2**) and exposing terminal ends 52,54, 50

5           respectively. While the sockets 42,44 are shown as being  
mounted within the hose 10, it is also within the terms of  
the invention to mount the sockets on the exterior of the  
hose, i.e. upon the cover layer 50, so that they can be  
10           5 easily replaced with other sockets depending on the  
particular installation. A user inserts plugs 56,58 of wear  
sensing devices 60,62 (described hereinafter with regard to  
15           **FIGURE 4**) into terminal ends 52,54, respectively, of two-pole  
sockets 42,44 to detect the degree of internal wear of hose  
10           10.

Hose 10 is generally constructed in accordance with  
20           techniques already known for manufacturing of hoses used for  
transporting abrasive materials. For example, hose 10 may be  
constructed with various inner diameters of interior surface  
15           11 as well as different final lengths. However, the hose  
25           usually has an inner diameter in the range of from 2.5 to 120  
cm (1 to 48 inches).

Another embodiment of the present invention may be  
30           considered (not shown) where sensor wire 14,16 is replaced  
20           with a chemical sensitive tape for application where material  
being transported is of a nature such that its presence may  
be sensed by means other than continuity. That is, the  
35           chemical sensitive tape can function as the sensor wires by  
indicating that the sensed layer about which the chemical  
25           sensitive tape is wrapped is worn by the absence of  
electrical continuity through the tape caused by chemical  
erosion or wear of the tape.

40           **FIGURE 4** shows a typical wear sensing device 60  
(substantially identical with wear sensing device 62)  
30           comprising an ON/OFF switch 72, a power source (not shown),  
45           an LED 74, a buzzer 76, a Push-to-Test button 78, a buzzer  
select/deselect switch 80, an optional remote output 82, and  
an industrial strength RCA phono jack 56 (comparable to plug  
50           58 of wear sensing devices 62) for connecting to the first  
35           and second two-pole sockets 42,44 of sensing elements 17,21.

5 Internally (not shown), the wear sensing device 60 contains a wear monitor circuit (described hereinbelow with respect to **FIGURE 5**) to monitor a wear sensing element 17,21 and control an alarm circuit.

10 5 Functionally, a wear sensing device 60,62 monitors a sensing element 17,21 by constantly checking continuity (resistance) of the circuit. A functioning circuit will measure a resistance, such as for example, less than 10,000 ohms that indicates that continuity of the sensing element is  
15 intact, implying that the sensed layer is functioning as required. Measuring a higher resistance, such as for example, greater than 100,000 ohms, indicates that continuity of the sensing element 17,21 has been broken, implying that the sensed layer has malfunctioned. In the latter instance,  
20 the functioning circuit activates an alarm 75. Alarm 75 consists of a flashing LED 74, an audible buzzer 76, and an optional signal from output 82 for a remote Programmable Logic Controller (PLC). Any or all of these alarms may be deployed, depending on the usage.

30 20 **FIGURE 5** shows a simplified block diagram of a hose wear monitor circuit 80 of a wear sensing device 60,62. The circuit 80 includes an Input Interference and Overvoltage Protection circuit 90, which connects by output 91 to a wear sensing system 19,23 and protects the corresponding wear  
35 sensing device 60,62 from external noise and voltage spikes. The wear monitor circuit 80 also includes a Resistance Monitoring circuit 92, which measures the resistance of a wear sensing elements 17,21 to determine if continuity is present. A Multivibrator and Oscillator circuit 94 flashes  
40 an LED 96 if an alarm condition is present. Using a Buzzer Select/Deselect switch 98 the operator enables an audible alarm 100. A separate transistor output 102 can also be included as part of the wear sensing device 60. A device such as a Programmable Logic Controller (PLC) (not shown)  
45 50 35 monitors the transistor output 102 to annunciate alarms in a

5 centralized control room or other remote location. A Push-  
to-Test switch 104 verifies proper operation of the wear  
sensing device 60. An ON/OFF switch 106 controls power flow  
10 to the wear sensing device 60 from conventional means such as  
5 a 6V battery circuit 108.

#### ALTERNATE EMBODIMENT

15 **FIGURE 6** shows a hose 110 constructed in accordance with  
a second embodiment of the present invention. Over a mandrel  
(not shown), an inner lining or tube 112 is applied, upon  
10 which a sensor wire 114 is spirally wound thereabout.  
Subsequently, an additional layer of insulating liner or tube  
20 116 is applied, upon which a sensor wire 118 is spirally  
wound. The free ends 114a, 118a of sensor wires 114, 118,  
respectively, are extended to or even beyond one end of the  
15 hose 110 and connect to a first two-pole socket (not shown  
25 but comparable to two-pole socket 42) as described  
hereinbefore. The other free ends 114b, 118b of sensor wires  
114, 118, respectively, are joined or spliced together to  
30 complete a first wear sensing element 119 (sensor wires  
20 114, 118 and two-pole socket 42) to detect wear in sensed  
layer 113. Subsequently, a layer 120 of tube or  
reinforcement ply is disposed over insulating tube or fabric  
35 layer 116. Layer 120 in turn has a single turn of sensor  
wire 122 spirally wound thereabout. A layer 124 of  
25 insulating tube or fabric is next applied, upon which a  
single turn of sensor wire 126 is spirally wound thereabout.  
40 Next, a reinforcement ply 128 is disposed over the layer 124  
and sensor wire 126. The free ends 122a, 126a of sensor wires  
122, 126, respectively, extend to or even beyond one end of  
30 the hose 110 to connect to a second two-pole socket (not  
45 shown) in the manner described hereinbefore regarding the  
embodiment shown in **FIGURES 1** and **2**. The other free ends  
122b, 126b of sensor wires 122, 126 are joined or spliced  
together to complete a first sensing element 119. It is  
50 35 within the terms of the invention to provide wires 122, 126

5 from a single strand of sensor wire that is simply applied on  
the inner layer 120 and then applied on the outer layer 124.  
The first sensing element 119 detects wear in sensed layer  
113. Subsequent layers of sensor wires, carcass fabrics,  
10 tubes and reinforcement plies can be applied using this  
method depending on the number of wear sensing elements and  
reinforcement plies required for the usage.

15 Completion of the construction of the embodiment  
presented in **FIGURE 6** is similar with the construction method  
10 described regarding the first embodiment illustrated in  
**FIGURES 2 and 3**. The second embodiment can be connected to  
wear sensing devices such as devices 60, 62 as described  
20 hereinbefore.

It will be appreciated by those skilled in the art that  
15 changes could be made to the embodiments described above  
25 without departing from the broad inventive concept thereof.  
It is understood, therefore, that this invention is not  
limited to the particular embodiments disclosed, but it is  
intended to cover modifications within the spirit and scope  
30 of the present invention as defined by the appended claims.

5 What is claimed is:

1. A hose (10) for transporting abrasive material including an inner lining (12), a plurality of layers (18,24,26,28,30,40) of reinforcement ply disposed over the  
10 inner lining, a first wear sensing element (17) disposed in a first sensed layer (13) at a first distance from the innermost surface (11) of the inner lining (12), the hose characterized by:

15 a second wear sensing element (21) in a second sensed layer (23) disposed at a second distance from the innermost surface (11) of inner lining, the second distance being greater than the first distance; and

20 a second wear sensing device (62), connected to the second wear sensing element (21) for providing an indication of and propagation of the hose wear to the second sensed layer (23).

25 2. The hose (10) according to claim 1, characterized in that:

30 the first wear sensing element (17) comprises a first pair of sensor wires (14,16) each having a first end (14a,16a) extending to a first end (10a) of the hose (10) and a second end (14b,16b) extending to a second end (10b) of the hose;

35 and

25 the second wear sensing element (21) comprises a second pair of sensor wires (20,22) each have a first end (20a,22a) extending to the first end (10a) of the hose and a second end (20b,22b) extending to the second end of the hose;

40 the second end (14b,16b) of the first pair of sensor wires (14,16) are connected to one another; and

45 the second end (20b,22b) of the second pair of sensor wires are connected to one another.

50 3. The hose according to claim 2, characterized in that:



5           the first pair of sensor wires (114,118) are insulated  
from each other by a layer (116); and  
          the second pair of sensor wires (122,126) are insulated  
from each other by a reinforcement layer (124).

10           5       4. A hose (10) according to claim 2, characterized in  
that:

          the first ends (14a,16a) of the first pair of sensor  
15       wires (14,16) are connected to a first socket (42); and  
          the first ends (20a,22a) of the second pair of sensor  
10       wires (20,22) are connected to a second socket (44).

          5. A hose (10) according to claim 4, characterized in  
20       that:

          the first and second wear-sensing device (60,62) for  
providing an indication of wear from the innermost surface  
15       (11) of inner lining (12) to the first and second sensed  
25       layers (13,23) are connected via the first and second sockets  
(42,44), respectively, to the first and second pairs of  
sensor wires (14,16,20,22), respectively.

          6. A hose (10) for transporting abrasive material,  
30       20       characterized by:

          an inner lining of elastomeric tube(s) (12), two or more  
reinforcement layer (18,24,26,28,30,40) applied over the  
inner lining, an outer cover (50) applied over the outermost  
35       one of the reinforcement layers, wherein the hose has a  
25       length and two ends (10a,10b), characterized by:

          a second wear sensing element (21), disposed in a second  
sensing layer 23 between the reinforcement layers, comprising  
40       a pair of sensor wires (20,22) running substantially the  
entire length of the hose, and having one end (20b,22b) of  
30       the sensor wires connected and the other end (20a,22a)  
45       connected to a second wear sensing device (62).

          7. The hose (10) according to claim 6, characterized in  
that:

5 the pair of sensor wires (20,22) of the second wear sensing element (21) extend spirally over the length of the hose and are connected at end (20a,22a) to a socket (44).

10 8. The hose (10) according to claim 7, characterized in that:

15 a first wear sensing element (17) is disposed between the innermost surface (11) of inner lining (12) and a first sensing layer (13).

20 9. A hose (10) according to claim 8, characterized in that:

25 the first wear sensing element (17) has two sensor wires (14,16), each having an end (14a,16a) at the one end (10a) of the hose and connected to a first wear sensing device (60), and another end (14b,16b) extending to the other end (10b) of the hose, and the ends (14b,16b) are connected to one another.

30 10. A hose (10) according to claim 9, characterized in that:

35 the sensor wires (14,16) of the first wear sensing element (17) extends spirally over the length of the hose.

40 11. A hose (10) according to claim 8, characterized in that:

45 the wear sensing element (21) is disposed in a second sensing layer 23 between the reinforcement layers which is farther from the innermost surface (11) of inner lining (12) than the first sensing layer (13).

50 12. A hose (10) according to claim 11, characterized in that the first and second wear sensing devices (60,62) connected to the wear-sensing elements (17,21), respectively, provide an indication to the user when the hose has worn through to the innermost wear-sensing element, thereby permitting the user to reposition the hose so as to continue operation until a failure of the second wear-sensing element to maximize the useful life of the hose.

55

5           13. A method of detecting wear in a hose (10) for  
transporting abrasive material, characterized by the steps  
of:

10           providing as least first and second wear-sensing  
5 elements (17,21) in the hose, the second wear-sensing element  
(21) disposed at a greater distance from the innermost  
surface (11) of an inner lining (12) of the hose than the  
15 first wear-sensing element (17); and

10           detecting a condition in each wear-sensing element  
(17,21), the condition indicative of a material being  
transported by the hose having abraded the wear-sensing  
20 element.

25

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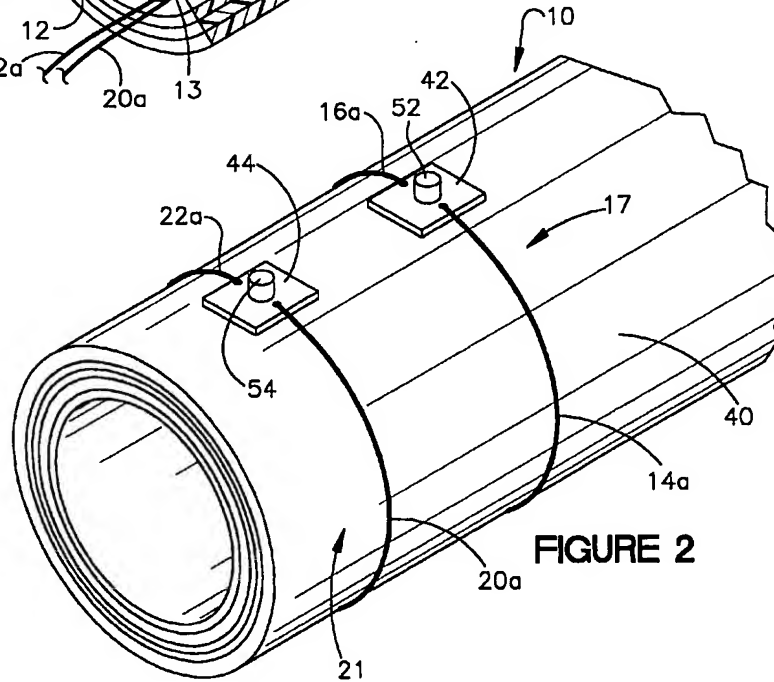
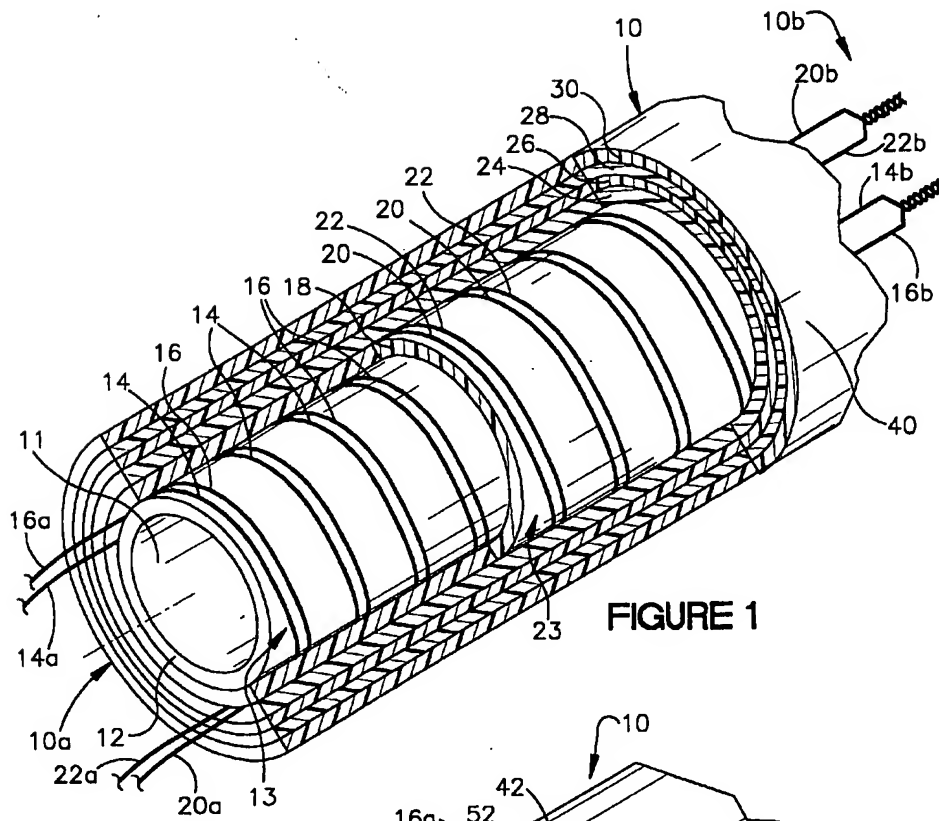
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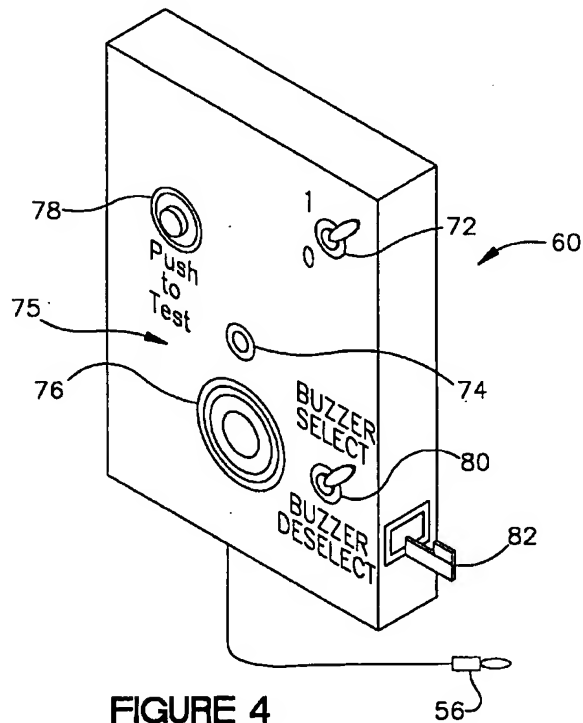
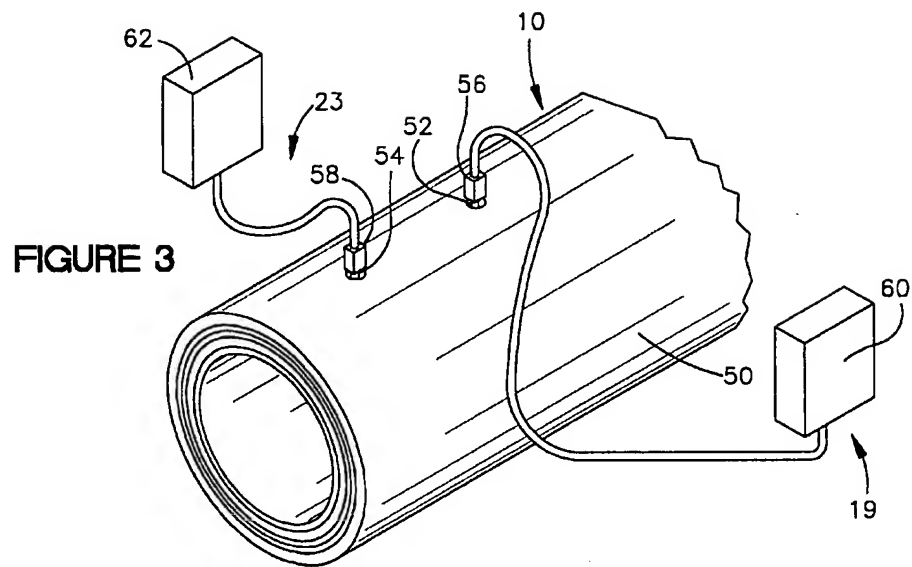
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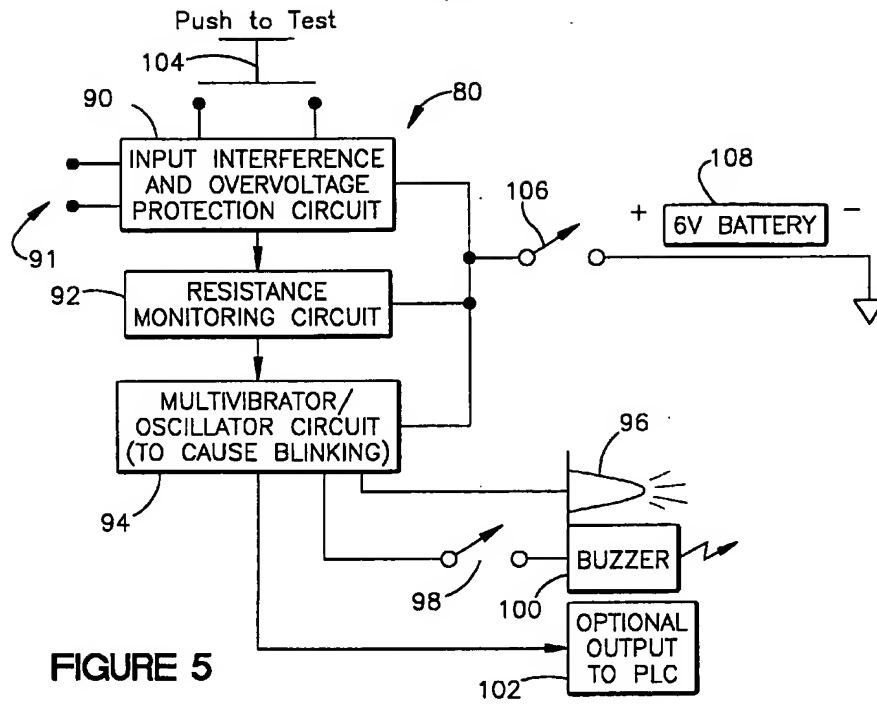


FIGURE 5

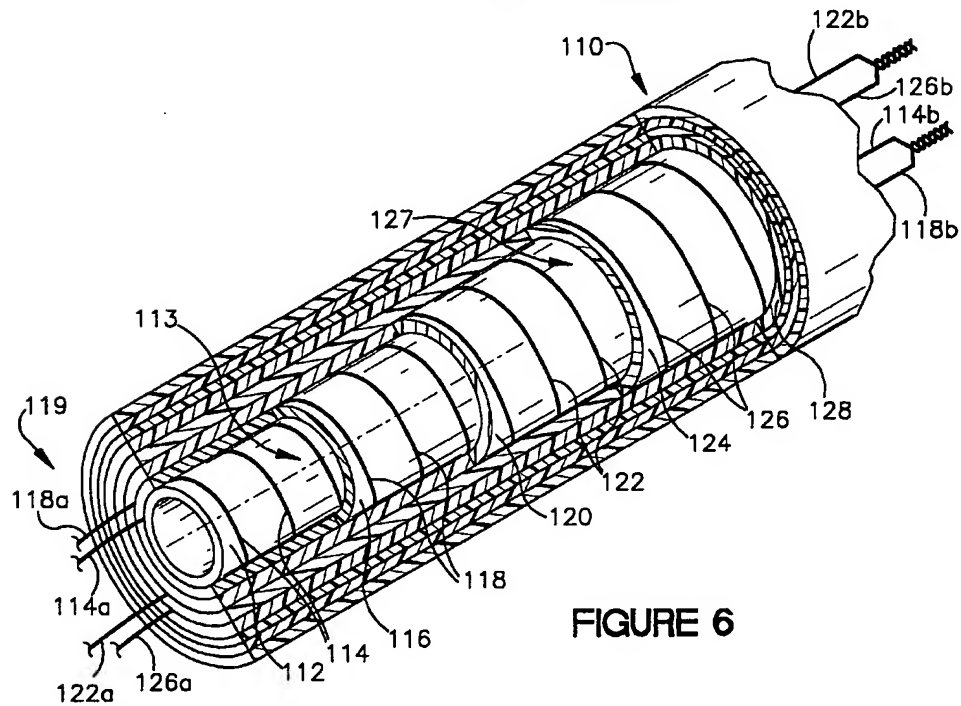


FIGURE 6

## INTERNATIONAL SEARCH REPORT

Int lional Application No

PCT/US 99/07899

A. CLASSIFICATION OF SUBJECT MATTER		
IPC 7	B65G53/52	F16L57/00 G01M3/18 F16L11/12
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols)		
IPC 7 B65G F16L G01M		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practical, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	column 4, line 52 -column 4, line 68; figure 2	2-12
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<input checked="" type="checkbox"/> Further documents are listed in the continuation of box C. <input checked="" type="checkbox"/> Patent family members are listed in annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "Δ" document member of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
14 December 1999		22/12/1999
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016		Authorized officer  Donnelly, C

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International Application No

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## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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A	US 4 474 217 A (DEMARSE ERNEST W ET AL) 2 October 1984 (1984-10-02) column 4, line 48 -column 4, line 53; figure 2 -----	1,13



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